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ANALYSIS OF SEA SURVEILLANCE OPERATIONS DURING THE CUBAN QUARANTINE

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Introduction

The subject of this paper is the CEG study of the Cuban quarantine operations, not of the operations themselves. The purpose is to describe for the benefit of other operations researchers some of the experiences and problems encountered in post-operational collection of a large and extremely varied mass of data and the difficulties of the subsequent analysis. Some of the results obtained will be discussed, as well as some other results which were not obtained. Finally, there are some suggestions as to how future jobs of this type might be done better.

Historical Comments on the Cuban Crisis

A brief background description of the Cuban crisis will be useful at this point.

The immediate causes of the Cuban crisis were Soviet introduction of medium range ballistic missiles (MRBM) into Cuba and abnormally high Soviet submarine activity in the area both of which were confirmed in mid-October 1962. The principal U.S. reactions were:

a. Concentration of forces in the Florida Straits area to prepare for military invasion of Cuba, if required:
b. Intensive air and surface patrolling of the Atlantic;
c. Proclamation on 22 October of a "quarantine," using naval force, if necessary, to prevent delivery of offensive weapons to Cuba;
d. Extensive operations in prosecution of submarine contacts.

These measures, along with President Kennedy's firm insistence that Soviet missiles and IL-28 bombers be removed from Cuba, achieved their aim. In the period 5-11 November, the missiles were removed, and on 20 November it was announced that the USSR had agreed to remove the IL-28's within 30 days.

The quarantine operation, as it turned out, was primarily an information-gathering operation, not a blockade. Those Russian ships at sea which might have been subjected to force to prevent them from bringing missiles to Cuba stopped and returned to Russia. This was apparently the result of the demonstrated U.S. ability to intercept them.

The operation evolved then into an attempt to locate all Soviet or other vessels which might be carrying prohibited materials to Cuba. For this, the surveillance forces tried to look at and identify every vessel in the Atlantic approaches to Cuba. Ships of special interest were designated to be tracked by aircraft or ships of the surveillance force. If surveillance or blockade were the only objective, line of minimum length could have been developed along the route Florida-Bahamas-Hispaniola-Venezuela. However, force requirements were affected by at least three major political military constraints:

1. A capability to intercept suspected vessels at a considerable distance from Cuba (initially 500 miles, later reduced);
2. The diversion of surveillance forces to search for and track designated special ships;
3. A requirement for surveillance of all shipping, not only those ships which were inbound toward Cuba.

Since "Show of Force" was one objective of the operations, there was no attempt to minimize the total forces used. However, to the extent that constraints on ship surveillance operations increased force requirements, the forces available for ASW were correspondingly reduced.

It was desired that any required intercept and boarding of a Soviet vessel take place at least 500 miles from Cuba in order to remain beyond range of the Cuban Air Force. Since the U.S. ships that would be involved in potential intercepts would receive their information from aircraft, this meant that aircraft searches would be made still farther from Cuba. In addition, a line too close to Cuba would give very little time for decision in what was obviously a critical and potentially explosive situation. If a suspicious vessel were detected relatively close to Cuban territorial waters, an

on-the-scene tactical commander might have to make a decision which the President and his advisors reserved to themselves. The need to detect and identify the incoming vessels well beyond 500 miles from Cuba therefore increased the perimeter to be searched by a factor of over three relative to the minimum line mentioned above.

Surveillance flights were made over an area of approximately 3 million square miles, exclusive of the Mid-Atlantic regions covered from Lajes (Azores), and were concentrated in certain areas. Patrol aircraft covered three zones. The first ran north and south from Puerto Rico to Bermuda and to the east and west of Bermuda. A second zone ranged from Puerto Rico to Jacksonville along the Bahamas and along the Florida and Georgia east coasts. Flights from Guantanamo toward the Bahamas also contributed to this coverage. The third area of coverage was just outside the territorial waters of Cuba, executed by flights from Key West and Guantanamo. In addition, flights from Lajes in the Azores covered selected mid-Atlantic areas.

Surveillance by surface ships was concentrated primarily in the quarantine barrier line initially stationed 500 miles from Pt. Maisi, Cuba and later repositioned closer to Cuba, just to the east of the Bahamas. (See Figure 1.) Ships also patrolled the passages such as the Florida Straits and Windward Passage. Because of the high density of merchant shipping in the narrow passages, these latter ships actually identified more ships than those on the quarantine lines. Thus, the surveillance coverage was a cross between area coverage and perimeter coverage.

In addition to systematic coverage designed to locate and identify all shipping in the Atlantic approaches to Cuba, many aircraft sortied to search for specific ships which had been contacted earlier or which had been detected by other intelligence gathering activities. U.S. Navy Ships were also assigned to intercept and follow designated ships of special interest. In the earlier part of the operation, these special search flights were given high priority. They altered the systematic search pattern and, in one case, took forces away from prosecution of a submarine contact. Sixteen of the Soviet ships enroute to Cuba stopped and eventually reversed course, which was an early indication of the success of the U.S. moves. Close coverage of

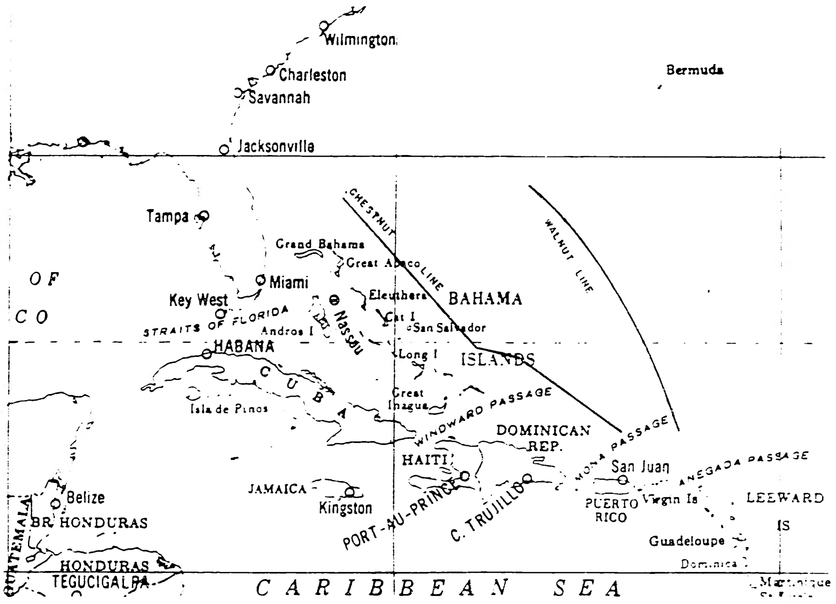

Figure 1

those Soviet vessels which did not turn back to Russia gave additional proof that the U.S. was maintaining control of the situation, as well as insuring us that prohibited war materials were not continuing to reach Cuba. After the USSR agreed to remove its missiles from Cuba, further special searches and tracking missions were sent to verify and count the number of missiles removed.

Background of the OEG Study

At the end of the quarantine operations, there was widespread feeling at various command levels that the "lessons learned" and unit experiences should be recorded. Operational units were instructed to preserve their reports and records for possible future analysis. However, the staffs involved had little time or manpower available to plan for analysis or to provide for data collection and reporting beyond what the reporting system and the operational messages and records supplied. This essentially ruled out any detailed analysis of aspects of the operation that would require reports or data that are not normally recorded.

OEG representatives on the staffs of CINCLANTFLT, COM2ndFLT, COMASWFORLANT, among others were already doing work connected with CUBEX, but had not prepared for the overall analysis, largely for the same reasons as their commands. Thus, OEG was not particularly primed for a study request.

The unit reports that were written were mostly narratives with some descriptive statistics which the units considered pertinent to their operations. There were no standard forms for the overall description or analysis of the operation, hence, it was not possible to combine individual reports without more information. For example, one unit might report statistics for the period 19 October to 10 November, and subsequently for 11 November to 1 December. Another unit could use different dates and report slightly different statistics. In order to aggregate the data of any two units, it would be necessary to go back to the original records of both and to extract comparable information on a standard form. This would have entailed a great deal of clerical work, some of which would to a large extent duplicate what had already been accomplished.

Thus, at the end of the Cuban crisis operations, a large amount of data existed, but a large amount of clerical work was required to transcribe the records. In addition, significant records of some less frequently studied aspects, such as command and control, did not exist in writing, or else existed only in unofficial forms or logs. It would have been necessary to act either during or immediately after the operation to preserve this information and to interview the appropriate persons while their memories were still fresh and before they were transferred to scattered and distant locations.

For at least two reasons, no action was taken immediately to start an overall study of the operation by collecting this information. First, most persons concerned had some "catching up" to do after a very hectic period. Second, in order to get the raw data collected and reduced to some extent, a heavy levy for clerical services had to be made upon fleet units. The officers most concerned in OPNAV were reluctant to do this. It was initially hoped that OEG might be able to obtain the required data from CNO flag plot. However, it became immediately obvious that analysis would be possible only with more detailed data. On 31 January 1963, 10 weeks after CUBEX, a CNO letter requested data collection. The records were sent to Norfolk and men were assigned temporary duty in Norfolk to transcribe the data. Thirty officers and enlisted men participated in March 1963, assisted by OEG representatives. Thus, over three months elapsed between the end of the crisis and the beginning of data transcription.

The original intent was to transcribe data on the movements of ships and aircraft and on the ships which they contacted and identified during the period 21 October through 21 November 1962. However, it became clear at the end of the first week's work that it would not be possible to complete this undertaking because there were too many reports. For this reason, the data period was shortened. The contact data were recorded only for the period 21 October through 7 November 1962.

The data fall into two major classes. First, data were collected to describe the location and the employment of the forces involved in the exercise. The primary sources for this were ships' deck logs and patrol aircraft flight logs. The aircraft locations could not easily be put into a form conducive to machine processing. For carrier-based surveillance flights, it was not possible to get any more detail than the location of the carrier and the times and numbers of sorties by aircraft type. The data supplies a record of how the flying-hours and ship days were allocated both geographically and by mission, during the period 21 October - 21 November 1962.

The second major portion of the data concerned the results of the surveillance effort. These were contacts and identifications. COMASWFORLANT received all the information on submarine contacts and prepared a report on the antisubmarine aspects of the operation. The OEG work was with the ship contacts and identifications. The basic data here were names (or partial names), positions, time, course and speed, nationality, and the identify of the unit which reported the contact.

At the end of the data transcription period OEG had data from nearly 900 patrol aircraft sorties, 6000 carrier aircraft sorties and 4000 ship days during the period 21 October - 21 November 1962. Over 4000 ship contacts with identifications were transcribed for the period 21 October through 7 November 1962.

It was obvious from the beginning that automatic data processing would be needed to handle the large mass of data transcribed. The forms for

transcription were created with this in mind. However, the lack of detailed analysis objectives at this stage caused less than optional use of the transcribing teams' time.

Difficulties in Subsequent Analysis

The difficulties in the subsequent analysis were in some cases due to the manner in which the study was initiated; in others they were inherent in the nature of the data plus, admittedly, shortcomings due to the analysts' inexperience and unfamiliarity with the operation. Most OEG data analyses result from fleet exercises or other operations for which the operations order contains a data collection or reports annex. The OEG representative on a staff which prepares the Op order can ordinarily help to insure that the reports require data in a usable form to provide answers to specific questions about the operation. These questions are formulated before the exercise occurs by the commands involved. Ideally, the major questions to be investigated, the data to be collected and the methods of analysis are determined in considerable detail prior to the operations.

In this study, the situation was far from the ideal. The analysts who were to make the study did not participate before the operations and were not present during the operations or for three months afterwards. Thus, they had no effect upon what data were actually available. The questions which were to be answered were first formulated at the time that the study began, and then only broadly.

The formal request asked for "evaluation of the force mix" and "evaluation of the impact of new vehicles," such as the P3A aircraft. The basic objective of the study was to learn from the operation and to put the results in a form suitable for future use.

More specific goals had to be, and were, stated by the time that detailed forms and instructions were needed for the group that would actually transcribe the data. However, we were not sure how well answers could be obtained from data which had not yet been seen. Also, many questions were recognized only after transcription had begun. Obviously, we needed a careful description of the resources used and how they were used and a description of the results of these efforts. Nevertheless, as is bound to happen in any complicated analysis, we thought of items during and after the data transcription that would be simple and easy to get if requested early, but impossible later. With the help of hindsight, many of these things now seem obvious. One of the few ways to lessen this difficulty (other than providing more perceptive analysts) is to take all possible steps to ensure that the analysts are as familiar as possible with the operations which they have to analyze.

The delay in assembling and transcribing the data affected the quality of the data with which the study was carried on, both in completeness and accuracy. When data were missing or obviously incorrect, it was frequently impossible to find anyone who could supply the correct information. It was difficult to ensure that all the data were actually assembled. A year after the transcription, we found that over 50 sorties of one patrol squadron had not been reported nor transcribed with the rest of the data.

Other problems are inherent in the type of operation and could not be avoided completely, regardless of how well the data collection might be planned. For example, it was necessary to describe the actual areas searched by the patrol and carrier aircraft. Even if every flight track were available, which was not the case, there would still be a problem of describing and defining the area searched simply enough for easy transcription from original records into machine language. In many cases, the surveillance tracks are specified in standing operations orders. There is a short code designation for each track, and so it is easy to transcribe. However, this does not lend itself easily to machine use unless there is a large number of flights on relatively few tracks. In that case, the description of the tracks and their designators can be transcribed and put on tape. When there is a large number of essentially different flights, the labor involved makes the job unmanageable.

Another difficulty is to specify the purpose of whatever a ship is doing. This doesn't sound like much of a problem, but it is often hard to extract from the ship's records the aim of its operation. The inexperience of some of the men transcribing the data and the analysts unfamiliarity with the operation added to the problem, because it is difficult to classify data in a meaningful way unless one has some idea beforehand what the major categories will be.

The problem which we had in computer operations with the data are not uncommon in an operation of this type. One of the more interesting problems arose because names of ships identified by U.S. ships and aircraft were reported in different spellings and with different amounts of garble. Some process was needed to determine whether two reports were for the same or different ships. After some experimenting, a computer program was written to compare ship names as reported and to associate names that differed by a combination of more than two substitutions of letters and or transpositions of letters. This worked well to associate such spellings as "Port Hudson" and "Fort Hudson" which do not come together in alphabetical listings. (See Figure 2.) The Cyrillic spellings of Russian merchantmen gave more trouble and had to be ferreted out by human inspection. "Bucharest" was reported in the anglicized spelling and also in Cyrillic. However, the Cyrillic letters were changed to latin in one report, with resultant garble, as shown. This kind of garble can be corrected easily without machine processing. However, "BELOVODSK" was reported "BEADBACK" on one occasion, clearly due to a garble of the Cyrillic letters.

ACTUAL NAME ON SHIP	REPORTED NAME	ENGLISH TRANSLITERATION OF CYRILLIC LETTERS
FORT HOSKINS	PORT HOSKINS	———
БУХАРЕСТ	GYXAPECT	BUCHAREST
БЕЛОВОДСК	BEADBACK	BELOVODSK

Figure 2

This problem will likely be encountered whenever there is an attempt at sea surveillance, and further work seems justified if computers are to be used to process reports.

The inaccuracies, incompleteness and inconsistencies of the data made writing and debugging the computer programs much more time-consuming than had been anticipated. In fact, some of the machine processing would have been done by hand if anyone had known in advance how long it would take to get the programs properly running.

Most computer programs assume some regularity and logical consistency in the data. When this is not the case, it is necessary either to edit the data to ensure that the computer processing will not be disrupted, or to include in the basic program some instructions to take care of special cases. If the programmer is aware of all special cases and types of error that may occur, then, subject to the accuracy of his programming, he can write a correct program without an unduly large amount of debugging time. However, when there are unanticipated difficulties in the data, the program simply requires more debugging runs as the unforeseen inconsistencies are removed. Generally, the CUBEX programs were "one shot" programs: when they were finally in correct form, just one "production run" using all the data was needed. The ratio of debugging time to production time was 2.5 to 1. In many computer applications, efficiency is achieved through repeated use of a single program. For example, a war-game program written at the same time as the CUBEX analysis required almost exactly the same debugging time, but the ratio of debugging to production time was only 0.05 to 1.

Despite this relatively inefficient use of the computer, there was no other way to handle the large amount of data that we had. However, it is evident that an experienced senior programmer is needed, even though the nature of the program may appear quite simple.

Results of the Study

The CUBEX analysis has resulted in:

a. Statistical analyses and descriptions of the force employment and its effects;
b. Estimates of the probability that ships passing through the surveillance area would be identified;
c. Performance figures for patrol aircraft surveillance operations.

The statistical description of the operations will be passed over quickly here. It is necessary for analysis, where comparisons between results and effort are desired, and it is of historical interest. Figure 3 shows the allocation of effort by patrol aircraft, carrier aircraft and ships. It should be noted that the surveillance operation was the main work of the patrol aircraft, whereas, ASW accounted for much of the ship and carrier aircraft effort.

The probability that any ship passing through the area would be seen and identified is one measure of the effectiveness of the surveillance operation. Of course, the primary purpose of the operations was to locate, identify and trail or intercept designated Soviet bloc ships, the probability of identifying any bloc vessel transiting the surveillance area is more pertinent. As it turned out, it was not possible to estimate the identification probability for bloc vessels only, but it was possible to make this estimate for a sample of ships, nearly all non-bloc, but including some ships with eastern European registries. However, the probability of locating and identifying any Soviet bloc vessel appears to be higher than the probability for ships in this sample, because additional intelligence was made available to the surveillance forces and special flights were ordered to look for specific ships and find them on the basis of such information.

Lloyd's Shipping Index Voyage Supplement, which provides a list of voyages and ports visited after the event, served as a data source. It is believed to have nearly 100% coverage for voyages between free world ports. No estimate of Soviet bloc coverage is available, although bloc ships are included in the listing.

The method used was to select samples of merchant ships with roughly similar paths through the surveillance area within the time period of the surveillance operations. Then the times and locations and the sources of identification, if any, were determined for each transitor. If the sample is "large enough" and "representative," then the percentage of sample ships identified is an acceptable measure of the effectiveness of the surveillance operation against all ships on the routes of the sample.

A total of eight samples was studied: two on roughly westbound courses and two on eastbound courses between Europe and the Gulf-Caribbean

	Westbound No.	Eastbound No.	Combined	
			No.	%*
Number of voyages	90	77	167	100
Different vessels identified				
in area east of quarantine line				
by ships	22	[illegible]	[illegible]	[illegible]
by landbased air	58	[illegible]	[illegible]	[illegible]
by carrier air	15	[illegible]	30	[illegible]
by combined efforts	64	[illegible]	106	63
in area west of quarantine line				
by ships	31	44	75	[illegible]
by landbased air	34	33	[illegible]	40
by carrier air	2	1	3	2
by combined efforts	50	49	99	59
in whole surveillance area				
by ships	43	46	89	53
by landbased air	64	59	123	74
by carrier air	17	16	33	20
by combined efforts	74	70	144	86

*Percentages shown in this table are percentages of the total number of voyages

Fig. 3. Numbers and percentages of east and westbound voyages identified by different surveillance force components

area, and four samples on north and southbound courses between the east coast of North America and the Gulf-Caribbean area. The results have been analyzed in considerable detail, but only a representative portion can be discussed here.

Figure 3 shows the results for a sample of 167 vessels, 90 on westbound and 77 on eastbound courses. 144 of these ships, or 86%, were identified by the surveillance forces. Landbased aircraft identified 123 of the 167 ships in the sample, or 74%. Ships identified 89, or 53% of the transitors and carrier aircraft identified 33 transitors, or 20%. The ships and carrier aircraft thus identified substantial fractions of the transitors and together made 122 identifications. However, due to duplications, only 19 of these represented ships which were not identified by the patrol aircraft.

The figure of 86% is probably an underestimate of surveillance effectiveness since 15% of the identifications made were "negative" identifications. That is, enough information was obtained for the reporting naval unit to know that the ship it located was not a bloc vessel, but not enough information to get the exact identity. For example, "passenger liner, French" is a negative identification. In addition, some of the reported names were so garbled that it was not possible to ascertain identities. It is believed that the percentage of identifications was 90% or higher, particularly against bloc vessels on which special intelligence and advance warning were available.

The study also provided performance figures for patrol aircraft which will be useful in planning for future operations. Figure 4 illustrates a result which to the best of our knowledge, has not been recorded elsewhere. This is a plot of P2

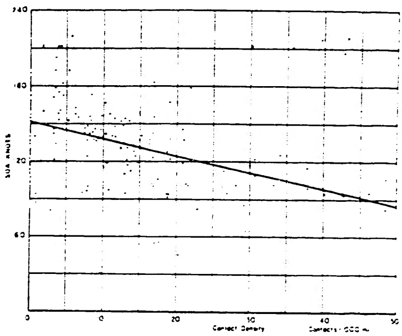

Figure 4

aircraft speed of advance along the surveillance track as a function of contact density. The plotted SOA was obtained by dividing the length of the planned surveillance track by the elapsed time for each flight. Because of diversions to investigate contacts, the speed of advance along the planned track is lower than actual groundspeed. The line shown is a least squares fit. It indicates a decrease of 1.35 knots in SOA for each additional contact per 1000 miles of track. This should be useful for future planning of surveillance operations.

Another type of useful result concerned expenditures and failures of sonobuoys in ASW missions. Figure 5, for example, suggests that the variability in expenditures is so great that the sonobuoy load

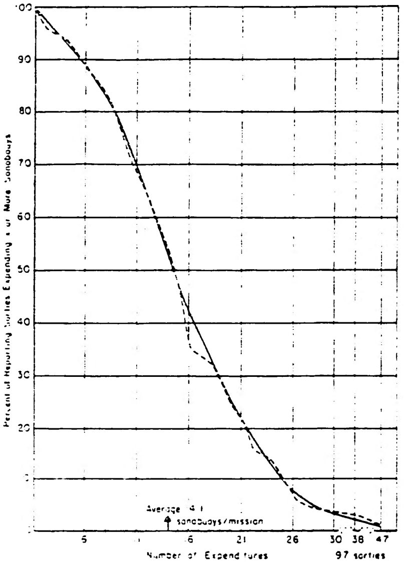

Figure 5

capacity must be on the order of twice the average number dropped per sortie.

Improvement of Future Analyses

A similar analysis conducted in the future could be improved by taking steps now to insure better and more complete data from any large-scale operation. Of course, there is no way to insure 100% completeness and accuracy in data collection. However, the quality of the data could be improved considerably if the analysis team were present during the operation and in a position to examine the data being produced.

One way to do this might be to get an analysis team ready to go to the appropriate command and to begin work as soon as possible in any significant operation. Obviously, such a team must include persons who are experienced or who are already familiar with the operations so that the team can function with a minimum of interference with those actually executing the operation. Such a team can be specified in appropriate OpPlans and check off lists and earlier decision can be made on the scope and nature of analyses to be performed. A source of difficulty is the fact that the nature of the operations is often not known precisely in advance. It is extremely difficult to anticipate all the reporting needs for analysis or, for that matter, all reporting needs of command. It is impossible to report on a routine basis everything required for every conceivable contingency. Many reports are not routine in peacetime, but are required under specific circumstances.

If a report is not routine, it is almost certain that there will be discrepancies the first few times the report is filed. Hence, it is desirable that as much basic information as possible be reported routinely, and that special reporting requirements are minimized and kept as simple as possible.

It can be observed that the various standard reporting forms manifest considerable redundancy. However, a major obstacle to simplification of collection and reporting of data is that the basic body of required information is generally to be found at different places and with different individuals. It is difficult if not impossible to assemble information without some redundancy, and it is necessary to transcribe information from original records in order to get one coherent collation. For example, information about a single ship's course, speed, position is normally logged on the bridge. Information about an ECM contact is logged in the CIC. Both sets of information may be available in both places, but the information is written down in separate places.

It might be worthwhile to examine the entire set of reports that contribute to the analysis of large-scale operations in the hope of simplifying by reducing redundancy and by putting many of the essentials on a routine reporting basis. Much presently recorded information could undoubtedly be as easily set down in a form which would permit easy conversion for machine analysis where desired.

As an example, consider a ship's quartermaster's log containing such quantities as course or heading, speed, position, time and changes in these. These quantities could all be recorded on a standard form with a special marking pencil and the completed forms could be handled automatically without further transcription. Thus it would be possible to enter the history of a ship's movements into a computer, eliminating much clerical labor and the possibility of errors in transcription or coding. Narrative information will continue to be needed, and could be entered beside or between sections of numerical data. Such standardization appears feasible; is compatible with machine processing; and, at the same time, might simplify routine record-keeping. Other aspects of the ship's condition and environment are as easy or easier to prepare in a manner suited to machine processing. Examples are: weather data, bathythermal data, equipment status, fuel states and usage, etc.

The major recommendations, then, for improvement of future analyses are:

1. Provide for a standby analysis team to begin the analysis as quickly as possible after the start of a major operation.
2. Revise required operational reports to ensure that, to the largest extent possible, the basic data required for analyses is reported

routinely, and preferably in a manner which facilitates machine analysis.

Summary

The CUBEX analysis differed from most analyses of operational data in that data were drawn from normal records and reports. The data had not been tailored for the purpose of answering specific questions formulated beforehand. Furthermore, analysts were assigned to the study and the data were assembled and transcribed fully three months after the end of the operation.

Thus it was learned (or relearned) how important it is to get analysts into the operations as early as possible. This allows for preplanning the data collection and analysis, permits analysts to familiarize themselves with the operation, provides time to formulate specific questions for analysis to resolve, and improves the likelihood of obtaining accurate and complete data needed to answer crucial questions.

This project also reinforced the feeling that much information which is routinely recorded or reported can and should be produced in a form suitable for machine processing. Much analysis common to many operations could then be standardized for computer processing, thus eliminating the inefficiency of "one-shot" programming.

Despite the difficulties experienced, useful and interesting results were obtained.